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(56) Documents Cited
EP 0241565 A1 **WO 94/27161 A1** **US 5483244 A**
US 5327144 A **US 5317323 A** **US 3793635 A**

(58) Field of Search
UK CL (Edition O) H4L LDSL
INT CL⁶ G01S, H04Q

(54) **Locating cellular radio transmitter**

(57) A method of locating a cellular radio transmitter (11) in which the relative times of arrival of a signal from the transmitter (11) at a plurality of receivers (12, 13, 14, 15) are measured by means of correlation and a triangulation operation is carried out to determine the location of the transmitter. The amplitudes of the received signals may also be used.

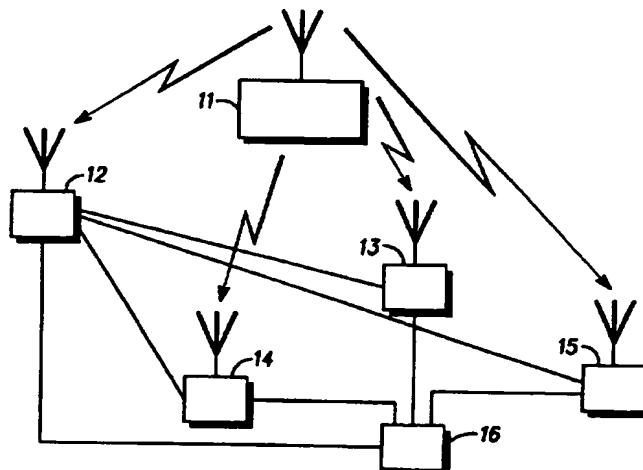


FIG.1

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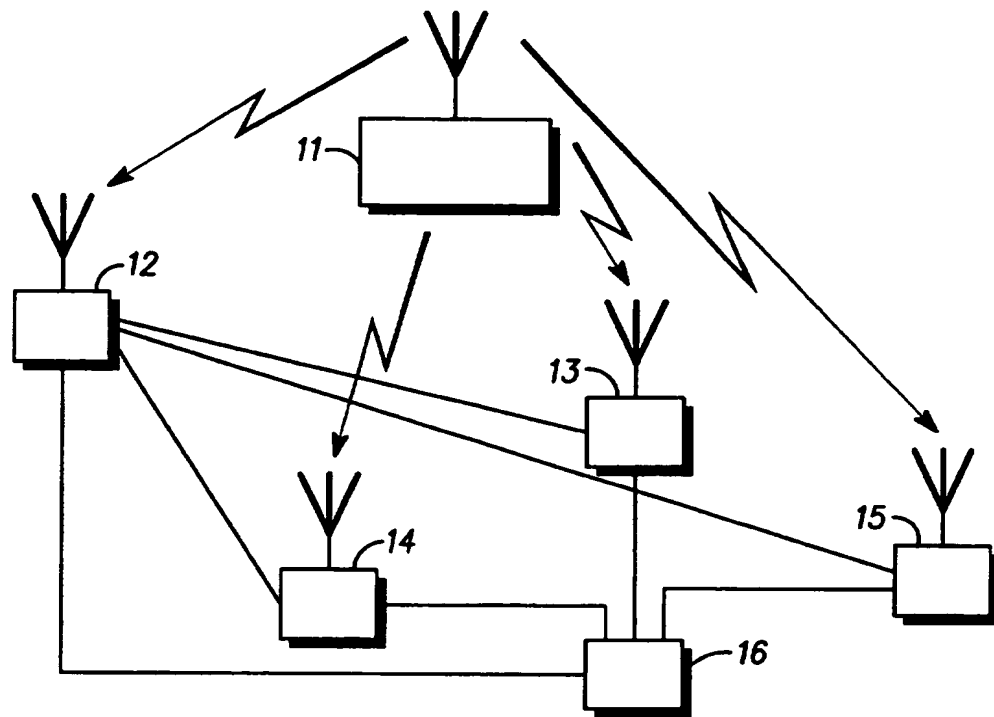


FIG. 1

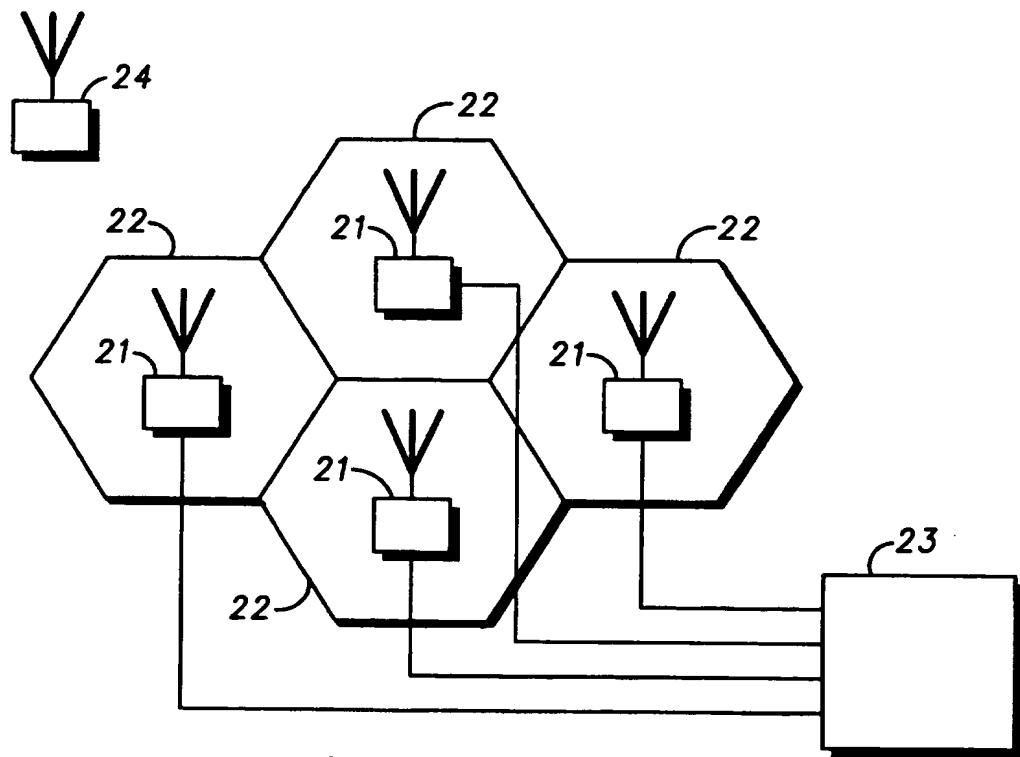


FIG. 2

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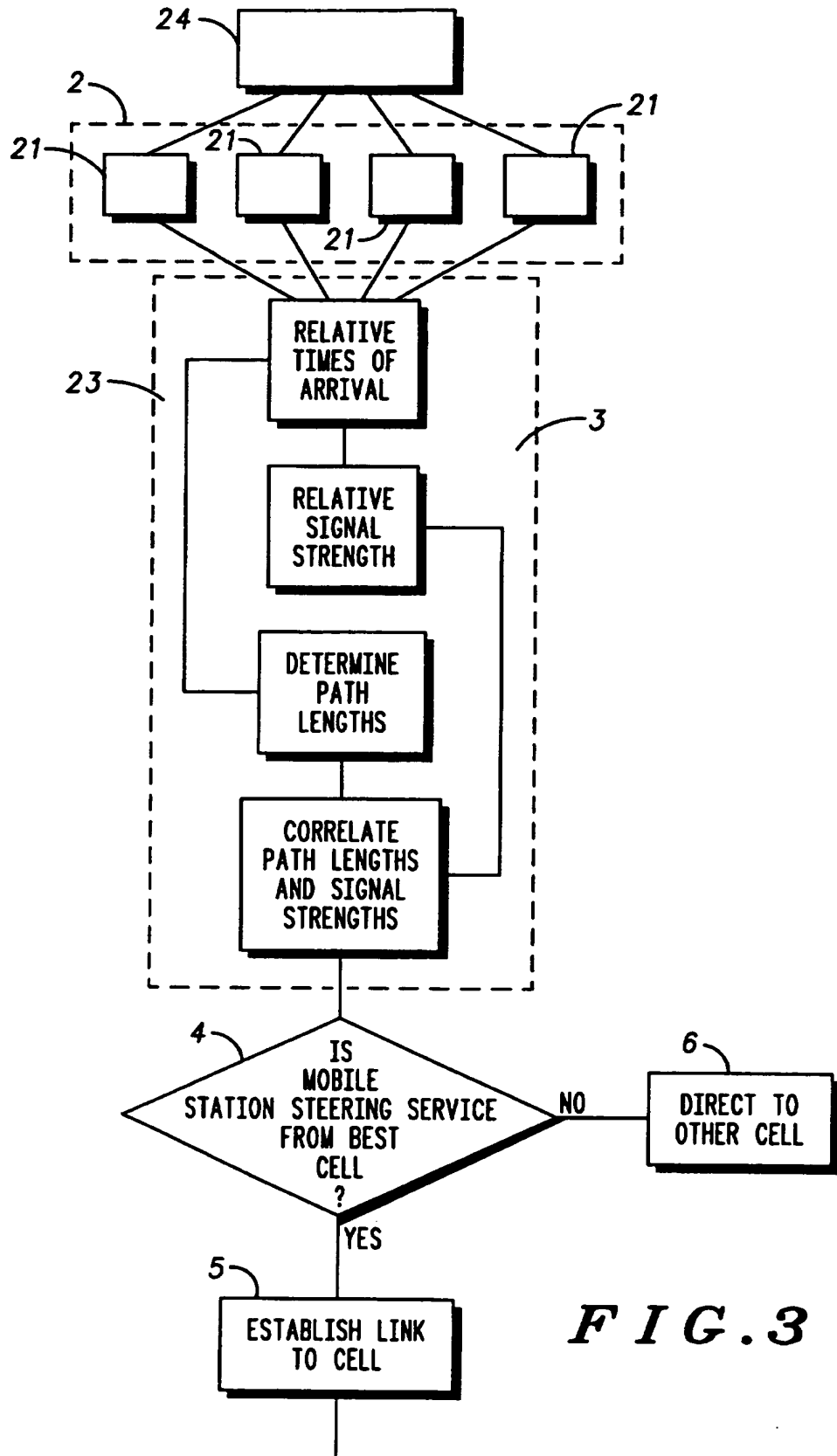


FIG. 3

Method of Locating Radio Transmitters

Field of the Invention

5 The present invention relates to the location of radio transmitters and more specifically, to the location of mobile stations in cellular radio communication systems in which each cell of the radio communication system includes a base station with which mobile stations communicate.

10 Background of the Invention

In cellular radio communication systems each base station operates at a specified frequency which differs from those of neighbouring cells. In order to increase the capacity for traffic within a cellular radio communication system it has been proposed that the size of each cell should be reduced, so
15 increasing the number of times a given frequency can be used within a given geographical area. However, as the size of the cells decreases, the risk increases that a given mobile station may seek to establish a link with a base station in a cell other than the cell in which the mobile station is
20 situated. This is particularly so for mobile stations which are moving at a speed such that they can traverse a cell in a time which is comparable with that required to establish a link with the base station of that cell. As a result there is a greatly increased risk that a given call will fail. Also, in areas where there may be a number of very small overlapping cells,
25 such as, for example, have been proposed for indoor pico cellular radio communication systems, the control of which base station provides service to any particular mobile station becomes critical to the prevention of interference between calls made within the system.

30 Summary of the Invention

According to the invention there is provided a method of locating a radio transmitter relative to a plurality of receivers, comprising the operations of determining the relative times of arrival of signals from the transmitter at
35 the receivers and deriving therefrom an indication of the location of the transmitter relative to the receivers.

There may also be included the operation of measuring the strengths of the signals received by the receivers and relating these to the respective times of arrival of the respective signals.

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Preferably the transmitter is a mobile unit forming part of a cellular radio communication system, the receivers are base stations of that radio communication system, and the signals received by the base stations are initial access request signals transmitted by the mobile stations.

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Brief Description of the Drawings

The invention will now be described, by way of example, with reference to the accompanying drawings in which Fig. 1 is a representation of a system for determining the position of a radio transmitter

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FIG. 2 is a diagrammatic representation of part of a cellular radio communication system and

FIG. 3 is a flow diagram of a method embodying the invention for locating a mobile station in a cellular communication system and determining with which base station the mobile station should be linked.

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Description of a Preferred Embodiment

Referring to FIG. 1, which shows schematically a system embodying the invention for determining the position of a radio transmitter II, four receiving stations, 12, 13, 14 and 15, respectively, are disposed in an array, the separation between the receivers 12, 13, 14 and 15 being known. Each of the receivers 12, 13, 14 and 15 includes an internal clock. The clocks of the receivers 13, 14 and 15 are synchronised with that of the receiver 12, which acts as a master. When the receiver 12 receives a signal broadcast from the transmitter 11, it produces a start signal which is applied to the receivers 13, 14 and 15. The receivers 13, 14 and 15 measure the intervals between the start signal and the arrival of the signal from the transmitter II at the respective receivers 13, 14 and 15. Data representative of these intervals are applied to a processing unit 16, which is adapted to convert the intervals,

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to lengths, perform a triangulation and provide an indication of the position of transmitter II in a convenient coordinate system.

5 If the position of the transmitter II is intended to be monitored by the receivers 12, 13, 14 and 15, then it may be adapted to produce a sequence of distinctive pulses. If it is not, then it may be necessary to carry out correlation operations between the signals received by the receivers 12, 13, 14 and 15 to determine the intervals between the receipt by the receivers 13, 14 and 15 of a portion of the signal transmitted by the transmitter II
10 selected by the receiver 12.

Referring to FIG. 2, there is shown schematically a portion of a cellular radio communication system which consists of an array of fixed base transceiver stations 21, of which four are shown. Each of the base transceiver stations
15 21 covers a localised area which constitutes a cell 22 of the radio communication system. In order to reduce interference between neighbouring cells 22 of the system, it is arranged that the base transceiver stations of neighbouring cells transmit at different frequencies. However, the base transceiver stations 21 are all capable of receiving either a common
20 frequency or a band of frequencies. A group of neighbouring base transceiver stations 21 is linked to a base switching centre 23, which is linked to the base switching centres of other groups of cells (not shown) the whole constituting the cellular radio communication system. Moveable transceiver units, known as mobile stations, only one of which, numbered 24,
25 is shown are free to move around with the area covered by the cellular radio communication system. As they do so, they communicate with the most appropriate base transceiver station 21. This is usually the one nearest to the mobile station 24 but not necessarily so.

30 As part of the operating procedure within the system, any given mobile station 24 seeking to communicate with a base transceiver station 21 transmits an individually coded initial access request signal, which is received by a number of local base transceiver stations 24. The initial access request signal is processed by the base transceiver stations 21, and/or the
35 base switching centre the most appropriate base transceiver station 21 is chosen, and a link is established between it and the mobile station 24.

A method embodying the invention for determining the location of a mobile station 24 with the area covered by the cellular radio communication system is illustrated in FIG. 3. Referring to FIG. 3, the initial access request signal, transmitted by a calling mobile station 24 (stage 1) is received by a number of local base transceiver stations 21, the positions of which are known (stage 2). The base transceiver stations 21 include internal clocks which operate either synchronously or with a known phase relationship. The synchronicity of the internal clocks in the base transceiver stations is maintained by the base transceiver station 23. Data relating to the relative times of arrival of the initial access request signal at the base transceiver stations 21, together with data relating to the respective received signal strengths are transmitted to the base switching centre 23. The base switching centre 23 carries out a triangulation operation using the received signal time data to locate the position of the calling mobile station 24 with respect to the base transceiver stations 21 and correlates this information with the received signal strength data (stage 3). The result of this correlation is used by the base switching centre 23 to determine whether the initial access request signal was picked up initially by the most appropriate base transceiver station, (stage 4). If the answer to this question is "Yes", the calling mobile station 24 is directed by the base switching centre 23 to establish a link with the original base transceiver station 21 (stage 5). If the answer is "No", the calling mobile station 24 is directed to establish a link with the base transceiver station 23 which appears to offer the greatest chance of establishing a successful link between the calling mobile station 24 and base transceiver station 21 (stage 6).

If the cellular radio communication system is one which operates according to the procedures established by the Global System for Mobile Communications (that is, a GSM system), or similar, then the actual operation of directing the calling mobile station 24 to the most appropriate base transceiver station 21 may be accomplished by a modified directed re try procedure.

If it is desired to monitor continuously the position of a mobile station 24, then the above location procedure can be carried out continuously during a

call, either using pre determined coded location signals transmitted by the mobile station 24 or by correlating signals from the mobile station 24 picked up by the base transceiver stations 21, as in the techniques described with reference to FIG. 1.

Claims

1. A method of locating a radio transmitter relative to a plurality of receivers, comprising the operations of determining the relative times of arrival of signals from the transmitter at the receivers and deriving therefrom an indication of the location of the transmitter relative to the receivers.
2. A method according to claim 1 wherein there is included the operation of measuring the strengths of the signals received by the receivers and relating these to the respective times of arrival of the signals at the receivers.
3. A method according to claim 1 or claim 2 wherein the signals include identification signals indicative of the radio transmitter.
4. A method according to claim 1 or claim 2 wherein there is included the operation of determining the relative times of arrival of the signals from the transmitter by carrying out correlation operations on signals received by one receiver and the other receivers separately.
5. A method according to any preceding claim wherein the transmitter is a mobile station of a cellular radio communication system and the receivers are base transceiver stations of that radio communication system.
6. A method according to claim 5 wherein the signals received from the transmitter are initial access request signals transmitted by the mobile station.
7. A method according to claim 5 or claim 6 wherein there is included the operations of measuring the strengths of the signals received by the base transceiver stations and combining the received signal strengths with estimates of the respective path lengths between the mobile station and base transceiver stations to determine the most appropriate base transceiver station to be linked to the mobile station and causing a link to be established between the mobile station and the most appropriate base transceiver station.

8. A method according to claim 7 wherein the cellular radio
communication is a GSM system as herein before described and the link
between the mobile station and the most appropriate base transceiver
5 station is established by means of the procedure known as directed retry.

9. A method of locating a radio transmitter substantially as herein
before described and with reference to the accompanying drawings.



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Claims searched: all

Examiner: Dr E P Plummer
Date of search: 5 November 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4L (LDSL)

Int Cl (Ed.6): H04Q, G01S

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP0241565A1	ANT Nachrichtentechnik - eg abstract	1,3,5,6,8
X	WO94/27161A1	Associated Rt. - eg abstract, page 33 lines 4 to 27, page 7 lines 13 to 20	1-3,5-9
X	US5483244	Motorola - whole document	1-3,5-9
X	US5327144	Associated RT - eg figure 8	1-9
X	US5317323	E-Systems - eg column 2 line 65 to column 3 line 14	1,3-6,8
X	US3793635	Sierra Research Corp - whole document	1-4

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